A new framework for the management of returnable "containers" within open supply networks

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Abstract. New logistics models – physical internet, pooling, control towers, reusable containers management – require an item-level traceability of physical shipping units that is independent of the partners involved in the supply chains. Current information systems architectures match this need by interfacing heterogeneous systems with each other. Such architecture can't meet the challenges brought by new and shared logistics models. We demonstrate here how the recent EPCglobal® standards and related technologies are settled in a multi-firm open network, applied to the management of reusable pallets, taken here as demonstrators of Open Tracing Containers (OTC). Material and methods for capturing data and structuring information are proposed and implemented in the Fast Moving Consumer Goods flows. Results illustrate the reach of that "Intranet of things" prototype, leading to interoperable logistic services, throughout various levels: from identifier tag level up to the piloting of each partner's logistics networks. We highlight limits and perspectives in terms of technical track and trace solutions and assets management in this environment.

Keywords: electronic product code, traceability, returnable transport items, standardization, open loop tracking.

1 Introduction

Logistics, as an activity committed to the management of physical flows, requires specific information systems, adapted to the logistic models in place [20]. Whatever their complexity, those management models are necessarily backed by information systems for locating and inventorying items, assets and vehicles [5].

Thus, new logistic models, such as the physical Internet, pooling, control towers, collaborative management of returnable transport items, require item-level traceability all along the chain and with every involved partner. In fact, whether we deal with a RTI flow piloting activity, or routing items through a physical internet network [2], shipping units are constantly consolidated and deconsolidated, so as to optimize shipping operations, and therefore, need to be traced and piloted at an item level.

For that purpose, underlying information systems have to be as independent as possible from the actors involved, so as to limit barriers to entry to those organizations, optimize communications, and limit inter and intra-firm interfaces [6]
According to [7] implementing those information systems are usually done through three different modes:

1. Solutions based on specific interfaces, developed on a case-by-case basis.
2. Solutions based on proprietary choices [19]
3. Solutions based on inter-firm standards.

This third mode, solutions based on standards, assumes a relative convergence of involved parties and their codification systems. As an example, it implies a common identification of each shipping unit, and implies that this data is shared and understood by all stakeholders, for easier flows and coordination.

This being so, each party of the chain, involved temporarily or permanently in those interconnected networks, must obey the shared protocol. The corollary of such an opening of this information system is that one must enhance data protection. The collaborative model calls for more shared data [15] taking into account relevant data rights, facilitating transfer while respecting data and business confidentialities. Then, this information and communication infrastructure offers logistic partners a common and uniform approach to information that limits and even eliminates informational interfaces, fostering collaborative logistic model's information's transfers [8]

In terms of informational architecture, the flexibility and resilience of the model we aim, calls for a distributed, modular and networked architecture [21] Web technologies have this capability and can also bring another form of sharing of a non-proprietary communication network [17].

In the following section, we will develop the various solutions developed in the industry in this matter. In a second section, we describe and position our experimentation case, before detailing our results and their analysis. Before that, we outline our subject of experimentation: returnable transport items.

2 Problematic

2.1 Returnable items management's specificities

The diversity and number of management systems in place, multiplies asset tracking procedures and corresponding information interfaces. This complexity combined to the fact that RTI activities are seen as peripheral leads logistics parties to consider them as a factor of cost, lacking any added value, a commodity.

New logistic models are backed on traceability systems where permanent localization of this logistic container can contribute directly or indirectly to the items transported and the vehicles carrying those various logistics units.

For that purpose, many organizations have tested the use of RFID technology for its productivity claim. This bulk reading by radio frequency, of items identifiers allows us to track items flows, on any site equipped by RFID readers, and to track them.

This capture of an identifier has to be enriched in a second time and published and shared so as to be accessible and useful for any party. The EPCglobal® standard can support this second part, by supporting inter-firm logistics information systems.

2.2 EPCglobal®, for RTI tracking in open loops

Whether they are for rent (Chep, LPR, Pick & Go, JPR, iGPS) or exchange pallets (EPAL), many pool managers have attempted to use RFID to pilot their assets pool. Despite those many pilot attempts, very few pool managers have finally adapted those means for identification and tracking.

The advent of the EPCglobal® standard [10] now supported by FMCG manufacturers and retailers, through their common association GS1, allows a convergent and unified approach of codification in supply chains. It offers a complete set of standards: tag level, XML messages (called EPCEvents), reader protocol, EPCIS databases, discovery services for Electronic Product Code (EPC) data, this standard sets a common "language" bound to address the principal aims of event tracking of object flows – assets or goods shipped.

Each object is then identified through its individual identifier: the EPC code (Electronic Product Code). To track them, logistics locations and vehicles must read this identifier and publish event messages at any equipped business-step: shipping, receiving, inventory, packing, controlling, and waste zone.

Those data are then published by the Internet on shared through standardized databases, known as EPCIS (EPC Information Services). Stakeholders have access and exploit those data, for their own purpose or their client's, assets owners, whether we deal with a closed (proprietary) or open (collaborative) loop [3].

This new way is an answer to logistic needs in terms of inter-operability of pooling solutions, routing, RTI management and, more broadly, as one of the likely technical frameworks for the emerging "Internet of Things".

2.3 The Kaypal® MR case

In this paper, we will describe a large scale implementation of such infrastructure, applied to the management of cardboard pallets used as interleaving logistics supports for FMCG goods shipped from manufacturer to retailer's distribution centers.

This product-service solution is called Kaypal® MR and is commercialized by its manufacturer: DS Smith since 2010. As the cycle describes, pallets, commercialized with a pay per use formula, are shipped to manufacturers, stored or cross-docked on retailers distribution centers and then recovered through the transport network. Supports are then sorted, aggregated for full truckloads repositioning on manufacturer's sites. At each step of this cycle, inventories inbound and outbound flows are declared through a dedicated web-service. Thus, the piloting of this pallet flow is fueled by those "declarative" data. The timeliness and accuracy of that information have then a direct impact on the knowledge about this RTI pool, its location and availability for further operations. The current business model of this service is based on pool-level

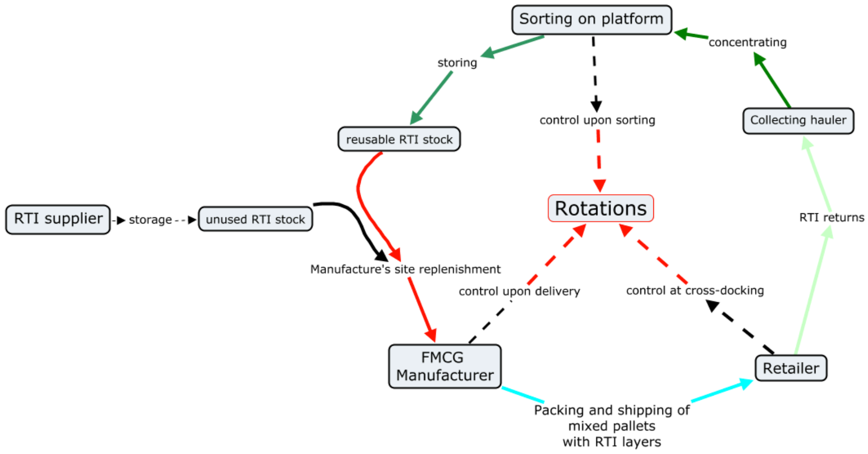

Figure 1. The Kaypal®MR cycle

calculations: cycle times, rotation rates, loss rates are known at the scale of the whole pool.

Improvement of repositioning solutions, pool balance, impact and responsibility of each element of this RTI chain requires the tracking data to be produced in near real-time, on shared databases, automatically, at the item level. Moreover, as these RTI are managed on an open loop model, the envisioned information system needs to be as neutral as possible, so as to represent a new tracking layer, as independent as possible.

RFID capture of a pallet level identifier, published through an EPC-based information system was chosen as the technical background supporting this new approach. Our field of study, the Kaypal® MR service, is this product-service offer were pallets are rented by DS Smith and physical flows piloted by 4S Network.

Our case study will help to illustrate adoption of this EPC standard [18]. The organization that is equipped with this whole disrupting infrastructure is dedicated to piloting a pool of Kaypal® MR pallets, used by approximately one hundred FMCG sites in France: 15 manufacturers, 60 distribution centers, one pallet factory and 7 transport providers that are in charge of collecting and re-injecting those palettes in the cycle. Within this collaborative organization, active since 2010 and rolled out since 2011, we implement the EPC Standard with corresponding RFID technologies so as to track those interleaving cardboard pallets.

The RFIDxEPCGlobal technological system limits the interfaces, listed in the first part of this paper, and will foster the design of shared information systems, opened but nonetheless secured. Building on this standard, partners are then allowed to design and implement fully inter-operable solutions that are less dependent on the information system already in place in the chain: ERP, WMS, TMS, EDI. Potentially, this standard could be one of the most appropriate frameworks for RFID tracking in open and collaborative environments.

Yet, before leveraging its full potential, many technological and organizational hurdles have to be solved.

3 Material and methods

The Open Tracing Container aims at designing a new RTI management model based on the EPCGlobal standard. This long term project, 36 months, involves 7 partners, associated with appropriate competences, in line with the new stakes listed above: a logistic and management lab, a Telco firm and its RFID lab, an RFID integrator, software developers and GS1. GS1 advocates the use of the EPC standard for transport and logistics activities. The corresponding author of this paper managed this project, called Open Tracing Container (OTC), on behalf of 4S Network and its client, DS Smith.

By this means, the experiment takes place on a RTI piloting service that has already been optimized since 2010 in terms of management of physical flows. We can then isolate the effect of the only new element to this system: The RTI RFID tracking solution combined with an EPC infrastructure.

This experiment started in October 2011 and will end in December 2014. Almost every pallet injected in the Kaypal cycle is now tracked through this OTC system, providing an accurate and real-time visualization of the 62000 transport items tracked and their content. The lifespan of this logistic asset is less than 24 months, and its mean cycle duration is 6 weeks. Thus it produces significant results early in the experimental process. Kaypal partners can then adapt those results to their operations.

3.1 Materials

We trace each of those pallets thanks to a passive tag that is sticked automatically to every new pallet injected in the Kaypal® MR cycle.
Pallets progression through the network are then read by 30 readers that are positioned on the cycle's strategic points, allowing to trace this physical pool individually and globally, and to assess the impact of client and logistic service providers sites on the pool.

RFID reading, converted in EPCEvents are then published on a network of four independent EPCIS databases controlled by the different actors of this chain: the pallets owner, the goods manufacturer, the retail chain distribution center, the transport group and the RTI service provider. Products information's (lot number, GTIN reference, SSCC reference) are also published by one of the manufacturer's sites on his own EPCIS database, allowing to jointly trace pallets and their products. In short, each role in the supply chain controls its own EPCIS.

Data thus distributed inside this network of databases can then be accessed through queries (pull mode) or subscription (push mode). The access control to those data strictly depends on the access rights one owns. EPC data processing then occurs inside OTC-Pilot, a kind of middleware application that produces generic RTI management indicators that are then broadcasted through this layer to operational parties and Objects (products and assets) managers and owners.

3.2 Experimentation method

3.2.1 Standard's layers in use

The EPCglobal® standard constitutes a common technological frame for the 6 types of stakeholders involved in the Kaypal® MR physical flow. Each layer of this system gets a serialized identifier: RTI get a GRAI code (Global Returnable Asset Identifier), sites a SGLN (Serialized Global Location Number), goods by their GTIN (Global Trade Item Number), shipping units a SSCC (Serialized Shipping Container Code), readpoints can also be identified by their GPS (Global Positioning System) position.
The first part of the GRAI code identifies the EPC-Manager, i.e. the owner of the tracked asset, the second part "Asset Type" identifies the reference of the RTI tracked: wooden pallet, cardboard, roll, etc. The serial number identifies each item (Figure 2)

This information system infrastructure is rather homogenous as any layer is standardized or compliant with the EPC standard. Besides, reader software is coded for Android 4.0 OS, allowing this reading application to be used on smartphones, whether they be capable of RFID reading or not. The readers are piloted thanks to a COTS solution, provided by UBI solutions, a RFID integrator.

	GS1 Company Prefix > < Asset Type	Check Digit	Serial Number (Optional)
0	N_1 N_2 N_3 N_4 N_5 N_6 N_7 N_8 N_9 N_{10} N_{11} N_{12}	N_{13}	X_1 variable X_{16}

Figure. 2. The GRAI Electronic Product Code structure.

3.2.2 Reader's type in place

On the pallet factory site we use two fixed but light readers. Manual readers are used on other locations. These mobile readers are scanner-type readers on logistic sites, and smartphone-type readers. The latter are combined to a RFID antenna and used onboard vehicles, where those smartphones are already in use for current transport activities. Those choices suggest a trend toward the use of non-specific reading material that can include an EPCEvent's publishing software, among other smartphone-like applications. Publishing is done through actual communication networks: warehouse WiFi connections, offices WiFi connections, 3G accesses already used by haulers drivers. We then can leverage on the communication devices and networks already in place within actual supply chains.

3.2.3 Chosen EPCEvents and complementary declarations

Three EPC-Event types are used, depending on the expected granularity and the composition of the tracked unit:

- Quantity Events to declare quantities of objects (pallets)
- Object events when the EC GRAI codes lists are read through RFID.
- Aggregation events when those EPC lists are aggregated

RFID-EPC captures are focused on strategic points of the RTI cycle: pallet tagging, truckload shipments of new or used pallets, goods packing, inbound and outbound movements. Extra readers are also used to track pallets collecting on distribution centers. By this means, one can visualize more thoroughly how many and which pallets are released out of the good's supply chain. Any RTI observation, coded in those EPCEvents can be combined with the declaration of the consignor or consignee sites those shipments come from, or are shipped to. Those voluntary declarations bring further visibility on physical flows upstream, or downstream from the focal readpoint.

Our incomplete RFID coverage is therefore combined with declarative data. By this means, from the observation done on location, and published, one can extrapolate on the previous or next location the objects are bound to be.

This principle is dictated by the moderate value of the object tracked, which business model wouldn't stand a rather exhaustive and therefore expensive tracking infrastructure. This information structure, combining ObjectEvents and QuantityEvents, proved to be suited to our logistics environment, and is fully in line with the new version (V 1.1) of the EPCIS standard, published in May 2014.

4 Results

This experimentation illustrates one way the EPC standard could be used within an open FMCG supply chain. The infrastructure settled is non-specific to the initial purpose: any EPC-identified object, site, client, asset, good… can be tagged and tracked through this system. As planned, this multi-purpose framework is characterized by limited specific interfaces: connection with a WMS, and OTC data communication through email or web services.

This experimentation has produced three direct results:

1. Tracking data: this data is mainly shared to optimize the RTI tracking service, at the operational and tactic level. They are also combined to goods tracking data so as to design container/shipped goods traceability. By this new mode of traceability, information are published, treated and spread through the OTC network. In case of tracking alert, parties do not have to cope with too many interfaces and have a more standardized and direct access to track and trace data. This disrupts from the actual mode where data is accessed through a cascade of queries through multiple proprietary transactional data systems. This second work-package of the OTC project also illustrates the way an EPC-compliant infrastructure could be inter-operable with current logistic information systems (ERP, WMS, TMS) of any of the chain partners. They communicate through XML messages communication or rather less sophisticated means: XLS files, e-mails. From September to June 2014, the OTC system has read, published and treated the circulation of more than 62 000 pallets, tagged at their manufacturer's premises, and then read all along their Kaypal® MR cycles. This data is representative of the whole flow of items as we almost tagged 80 % of the current active pool. Indeed, the reading rate of the flows both depends on the tag response (usually near 100%) and this latter proportion of tagged items (here, over 80%). Nevertheless, the readers in place proved to be capable of reading 99.99 % of a whole truckload (924 items).

2. An OTC architecture: This architecture is designed to proceed to a first series of data processing of increasing granularity: from the object level, to the shipment, up to the pool level. Logistic sites and service providers are also qualified and tracked.

3. KPI: Our main RTI indicators are: each object's trace their performance (cycle count, condition age) for any object and for the RTI pool as well, being it active or already scraped. Sites managing this physical flow are also assessed in terms of destruction rate, retention duration and also provider/client relations between the parties. At last, the RTI pool is sorted by condition: active, destroyed, inactive, loss, and by location (figure 3).

In our case, 8 different states have been defined and calculated:

- Active, when pallets have been read within the RTI cycle in the last 6 weeks
- Active on transporter's site : (here 5887 units) : read on a transporter's premises
- Active still in stock : not injected in the RTI cycle yet.
- Inactive : pallets that have not been read and tracked for the last 6 weeks
- Lost, shrinkage : not read for the last 12 weeks, likely to be lost or reused

Our results are consistent with the current Kaypal industrial dashboard, while being more fine-grained:

a. The number of cycles spans from 1 to 15 cycles recorded through RFID
b. The duration of those cycles spans from 2 to 20 weeks
c. The age composition is made from the individual track of 62000 objects

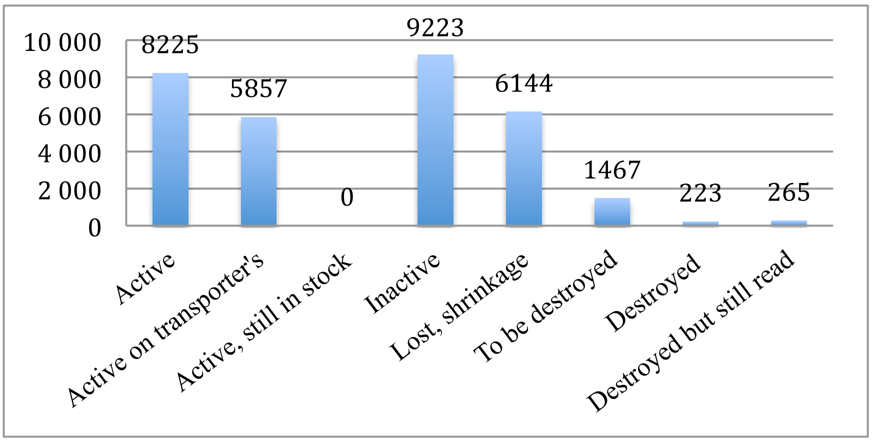

Figure 3. Pallets sorting by the Open Tracing Containers information system

4.1 Results exploitation.

Those RTI-centered KPIs complete the current dashboard used to manage the pool. The item level tracking brings better and finer knowledge about the pool: distribution by age, cycle time, cycle count.

Once used by RTI managers and service providers, they allow further optimization of the extent network, extended and facilitated access to tracking data, movements anticipation and control, by the means of shared or specific dashboards. The impact of this new framework on the actual Kaypal process will be tested and validated from June to December 2014. From this point, one can prototype other EPC-based services: RTI fine tracking, networked goods traceability [13].

4.2 Expected applications

Through a field study, we are now willing to expand the use of such model. For that purpose, we run a field survey so as to better assess how this model could address other logistics organizations also focused on assets or supply management. Retailers, pool owners, manufacturers are interviewed. Next cases of application could be closed loops [12], as well as open networks. Results of this enquiry will be presented in a forthcoming paper.

5 Discussion

Beyond the operational results described above, the results of this experimentation illustrate how one can implement a prototype of "internet of things", or more precisely an "intranet of things" [14], where logistics objects and sites are traced and assessed, through publications and EPC-data processing.

This renew our view on logistics assets, such as the pervasive shipping pallets or any other kind of container, are identified at the most fine level: the item-level. Thus, this rather commoditized asset gets a personal identifier and can then be a crucial asset in term of Event-based tracking. The once commoditized asset becomes a logistics activities "tracker", whether they directly deal with the RTI or not. We here disrupt this "container's" very identity [11].

In terms of organization and information system governance, our findings highlight pre-requisite rules for Event-data access. We noted here that the EPC-manager - the one that has tagged the objects tracked - would have a privileged, but not exclusive, access to most of the data. Nevertheless, other parties can decide not to give access to their readings of the EPC code occurring on their sites. In that case, contractual rules between parties would help to arbitrate and refine data access rules. Those access control rules are set at the higher levels of the infrastructure: EPCIS, Middleware or client application (here: OTC-Pilot). Yet, this crucial question remains open.

5.1 Experimentation's reach

The new architecture tested by the Open Tracing Container consortium and Kaypal users, has a networked, distributed, decentralized logic that help OTC-users to get partly rid of the interfacing strain.

In the first place, this model does not aim systems integration or application specificity. Therefore, a rather extended GS1 community could leverage this new OTC layer, which brings flexibility, compared to more "proprietary" schemes, like ERP. Nonetheless, in the context of OTC-businesses development, a certain degree of integration has to be coped with, as we experienced, while trying to design products EPC-based traceability. We then have to combine event to transactional data, with the help of the forth type of EPCEvents: TransactionEvent.

In terms of deployment, the budget size of the OTC (Open Tracing Container) project had a real impact on technical and organizational choices that built the proposed framework. Here, data capture remain mainly done by manual scanning, aligned to the usual code-bars processes in place. We then have to cope with non-automatic and non-systematic reading by hand-held readers. By this means, we do not fully profit the advantages of RFID capture: no need for line of sight, bulk identifiers capture, automatic reading. At this stage of experimentation, the tracking solution we designed isn't fully EPC/RFID and still remains influenced by the dominant design's logics of identifier capture and classical data processing [4]. We here can see that the initial logistic scheme remains a strong driver of the – deterministic - proposed solution [9].

Nevertheless, the uncoupling of physical flows and their informational trace shows a real potential in terms of service design that is still unexplored, where the logistic model is fuelled with "fine grained" data, available anytime through a shared EPC infrastructure. This would help operations to better anticipate and control assets flows, and better design routing solutions. Joint knowledge of this flow and the assessment by scoring of cycle sites would also help to better manage the whole pool.

This OTC experimentation highlighted the potential of the third mode [7], presented in the introduction to this paper, serving new-style collaborative solutions. Although being focused on pallets tracking through their GRAI code, this framework also proved it can process other EPC codes, read separately or combined as aggregates: SSCC, SGTIN, SGLN. This data pool is then exploited through initial piloting services, or could be used through novel approaches in terms of product traceability, leveraging as such an extended functional reach of this RFID/EPC framework:

- Initial Kaypal® MR traceability services managed by the 4PL (4S network)
- Product traceability managed by a 3PL LSP
- Vehicle tracking by transport companies, their clients or data processing

The economies of reach we presently underline have already been partially tested on nearly one quarter of the Kaypal® MR sites. Building on those first findings, OTC project partners have already identified ways to further exploit the potential of this framework. This new layer acts as a business-enabler where, on the base of a common pool resource (data and IT modules) various services can be designed, provided the parties have full or partial access to the elements of this new information system. In order to run those new models, logistic professional have to cooperate with EPC specialist, in order to fine-tune their EPC-based information system. Software development, EPC expertise, readers' management and many other highly technical aspects have then to be understood and mastered. Thus, implementing a logistics "intranet of things" is not only a question of logistics competences, but has to involve IT and data mining specialists.

6 Conclusion

Those findings about the use of the EPCglobal® standard in open environment, to improve RTI tracking, give a glimpse of the full potential of such an information and communication infrastructure, in terms of codification, capture, broadcasting and exploitation of item level data.

The new relation to the edition, repositioning, exploitation and business development announces a new type of governance for a more distributed, inter-firm information system, fostering information sharing within coopetitive supply chains, experimenting new logistic models. Nevertheless, industrial scale applications are still to be designed developed and used at a larger scale. Business and technical issues have to be solved, for supply chains members to leverage this framework's potential.
The next step is to learn from the experience at several levels: data accuracy, RTI management improvement, economic feasibility and foreseen new business models enabled by this individual traceability.

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